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ABSTRACT

A general outline of the topics that might be covered in a computers and computing course for high school students is provided. Topics are listed in the order in which they should be taught, and the relative amount of time to be spent on each topic is suggested. Seven units are included in the course outline: (1) general introduction, (2) using computers for learning, (3) information retrieval, (4) computers in creative arts, (5) modeling and simulation, (6) artificial intelligence, and (7) conclusions. The units are subdivided into anywhere from two to seven lesson plans, each of which emphasizes three out of the following four strands of content: applications, programming, computer environment, and social impact. Lists of resource books and periodicals are provided at the end. (TE)

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An Introduction to Computing: Content for a High School Course

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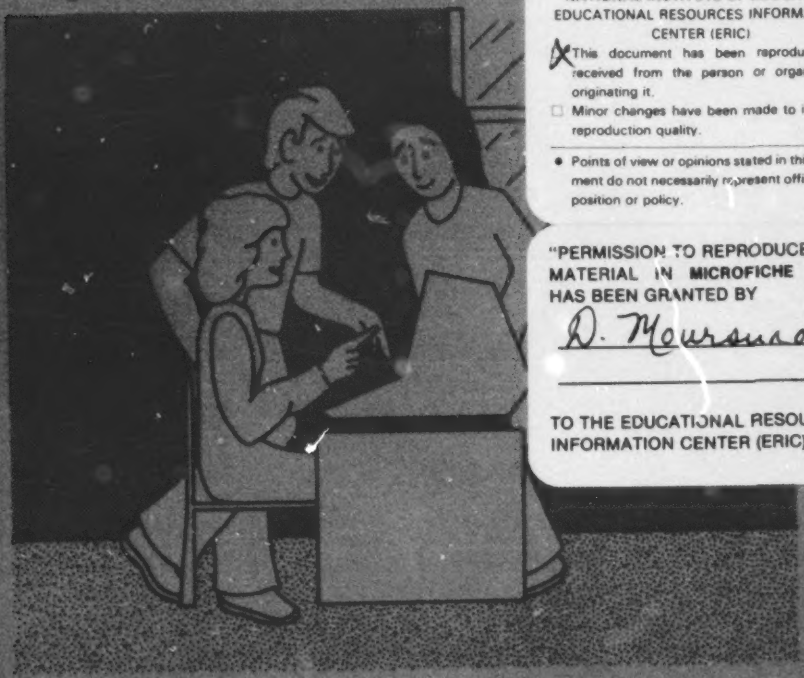

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INTRODUCTION TO COMPUTERS IN EDUCATION FOR ELEMENTARY AND MIDDLE SCHOOL TEACHERS

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Price $7.00 U.S.

INTRODUCTION TO COMPUTERS IN EDUCATION FOR ELEMENTARY AND MIDDLE SCHOOL TEACHERS by David Moursund is an 8½x11, 96-page book designed for self-instruction or for a formal inservice or preservice course for teachers. The book is suitable for teachers at all levels and is often used as a text for elementary or secondary school teachers. It contains an in-depth treatment of teaching about and teaching using computers at the elementary and middle school levels. The book includes over 75 activities that can be used at this educational level.

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An Introduction to Computing: Content for a High School Course

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INTRODUCTION

The course outlined in this booklet, *An Introduction to Computing: Content for a High School Course*, is specifically designed for students at the secondary school level. It is intended to be a general education course to be studied by every student, not restricted to students who are in advanced science and mathematics programs.

In this way it is very similar to the introductory biology courses taught at this same level. In biology the students learn some basic concepts about the life sciences that are important to every person who lives in our world. Similarly, in this introductory class in computers and computing, students will be learning concepts essential to living in our modern, computerized society. In introductory biology courses we are not training biologists or laboratory technicians. In the same sense, students in this introductory computer course will not be trained as computer scientists or programmers, but will gain a base of essential knowledge from which they can move to more specialized courses if they choose to pursue these career options.

This course is not a mathematics course. Learning computer use has often been thought to require sophisticated mathematics, especially when computer use has been taught by math departments, but mathematics is only part of the computing field. A large part of the information processing done in commercial applications involves words and pictures rather than numbers. Students can learn a great deal about computing without having to encounter much mathematics. Most computers currently being used in educational settings have built-in word and graphics capabilities well suited to providing instruction in nonmathematical computer uses.

Throughout this course, as each new topic is introduced, the ways computers are used by individuals, especially students, are presented. Through this focus on personal computing applications, students will learn about computer use as it applies to them, and then as it applies to other people and organizations. After students see that computing is a useful activity for them, they will see computing as a tool that can be used in many ways to help people meet their everyday goals.

There are four strands woven together to form the course described in this booklet. Each strand has its own content, but each is closely related to all the others. The four strands are:

This course is designed to be consistent with the recommendations of the Association for Computing Machinery Task Group on Computer Science in the Secondary Schools (see *TOPICS, Computer Education for Elementary and Secondary Schools*. Joint Issue of the Education Board, SIGCSE and SIGCUE. New York, NY: ACM, 1981).

Applications—how computers are used as tools in many different kinds of tasks.

Programming—how people give direction to computers so that the computers will perform the desired tasks.

Computer Environment—how the physical and organizational parts of computer systems work.

Social Impact—how computers and information processing create change in our society.

While the emphasis given to each of these content areas may vary according to the preference of the individual teacher and the individual class of students, topics in each of these four strands should be given attention throughout the course. In the Course Outline which follows, these four strands are coded as **A, P, CE** and **SI** respectively.

To teach this course, it will be necessary for a school to have some computer equipment available for the students to use. The best situation would be for each student to have unlimited access to a computer with an extensive library of good quality demonstration programs. A more probable situation will be one microcomputer for every 5-20 students. Absolutely essential, however, are some good demonstration programs, and virtually essential is an interactive computing environment.

Having an adequately trained teacher is another very important consideration in implementing this course. The subject matter being taught here is very modern and continually changing. Additionally, standard courseware materials are quite rare in this subject area, so the teacher will be forced to create much of the teaching materials needed. To teach this course the teacher should have a background that includes at least eight or nine term length (quarter system) undergraduate level computer science courses, or the equivalent in self-taught knowledge. Teachers with less background than this in computer science should plan on gaining at least this level of expertise to be able to adequately teach this course.

This booklet provides a general outline of the topics that might be covered in a computers and computing course for every student at the high school level. It delineates a list of topics, the order in which they should be taught, and some perspective on how much time might be spent on each topic. Each of these topics has been chosen because of its importance to a general knowledge of computing, but each topic is also important in the field of computer science. The course is designed as a logical whole, with a gradual development of generalized concepts which should prove very valuable to students in dealing with future decisions about computer use.

The next few pages provide some implementation suggestions for the teacher. Following that is the suggested course outline for 32 weeks of lessons. One page of this booklet is devoted to each week of the course. The final section of the booklet is a resource list, including some of the sources of information that should be of help to the teacher in creating a quality course in computers and computing.

SUGGESTIONS FOR IMPLEMENTATION

Teaching the course described in this booklet will be a challenging task; it will also be an interesting and exciting one. The opportunity to learn this material is very important to the education of your high school students; it prepares them to live in a modern computerized society.

Four strands are interwoven throughout the course, each an important part of the overall topic of computers and computing. These four strands are:

Applications

The computer is a tool that can be used in many different situations. A very important concept in the construction of this course is that students should learn how computers can serve them personally, and from that knowledge, should project to the ways computers serve others and the society in general. By using this approach, students should find they have a personal investment in learning about computers and computing. They will therefore see the course material as being well worth learning.

Programming

Learning at least a small amount of programming is necessary for any individual to fully realize that a computer is in fact not a magic black box, but simply a machine that is controlled and controllable by human direction. Students at this level will not become sophisticated programmers, but they all should acquire a general appreciation of what programming involves. To accomplish this, all students should do some programming. You should make your own choice of the programming language to be used; in this booklet, BASIC is the language referred to, but this course can be taught using other programming languages. Some students may be able to do some significant computer programs, but there may be other students for whom this is not an appropriate expectation. You might consider having some students do programming projects, while others do research papers instead.

As a related part of learning about programming, students should have some experience in programming as a team. Since much professional programming is done by teams, this experience will give students perspective on software produced this way, as well as practice working in a group. Some activities, such as experiencing a CAI program, will be done by each student individually. Arranging team programming may be somewhat more difficult than giving individual assignments, but should nevertheless be done throughout the course.

Be sure also that the programming assignments you give are not entirely centered on math topics. This is an easy trap to fall into because math and computers do work well together. There are many other computer applications, however, and many of your students will be much more comfortable with non-math programs.

Computer Environment

In this segment of the lessons, students will learn something of what computers are and how they work. People should have some idea of the technology behind any tool they use, but this does not imply that they need a very detailed understanding of it. The important goal is for students to learn how machines make it possible to do the information processing that is currently done, and the processing that might be expected to occur in the future.

Social Impact

A very important part of learning about computing involves looking at the effects computers have had on society. Use of automatic data processing has caused considerable changes, and we can expect such changes to continue. Students should gain some insight into the way these changes have come about so that they will be able to deal with future changes as they happen, and to consider potential changes before they happen. In teaching the subjects in this strand of the course, some philosophical questions will have to be addressed. Open ended classroom discussions will be an essential part of instruction with these subjects.

In the last section of this booklet is a resource list of some books and periodicals which should be helpful in preparing to teach this course. It is by no means an exhaustive listing of all the material that might be used. You will find it very useful to keep a file of articles from newspapers and magazines. The greatest part of non-technical material published about computers and computing is available through these sources. People who have been teaching courses similar to the one described here find that they can set up a file of such material and keep it updated quite readily. Computing is as pervasive in everyday publications as information processing is in modern society.

As a whole, this course is designed to provide the student with a broad understanding of what the use of computers and automatic computing means in the world in which the student lives. By gaining this breadth of understanding, students should be prepared to make decisions about computer use, both for themselves and for humanity.

The article which follows has been reprinted from another ICCE publication, *The Computing Teacher* (Vol. 8, No. 4, Jan. 1981). It contains some suggestions about teaching programming and programming style that could appropriately be applied when teaching *An Introduction to Computing: Content for a High School Course.*

ABOUT TEACHING COMPUTER SCIENCE

Every autumn a large number of precollege level teachers become something they've never been before: computer science teachers. A discouragingly large fraction of these people have had no training in being a computer science teacher before they become one. Fortunately, however, many find that they can transfer their skills in other subject matter disciplines into their teaching of computer science.

One important facet of computer science is *problem solving.* Teaching problem solving methods is an activity common to almost all disciplines in the school environment. Traditionally, the mathematics curriculum has taught problem solving most overtly, instructing students in tactics for problem analysis, and providing them with knowledge about the tools that their culture has built for them to use on problems. But just as the long division algorithm and the formula for compound interest are problem solving tools, so are scientific experimentation, budgeting of time and resources, and many other skills.

Consider, for example, a shop class that wants to build a small building for a class project. First they must decide some general questions: what kind of a structure, what type of materials to use for parts such as siding or roofing, where to get the materials. Answers to these questions then yield subproblems, to be broken down further until the individual steps of the project are clear and can be acted upon. This process is the same top-down analysis that is taught in computer science.

A second important part of computer science instruction involves considering the *place of computing in the world in general.* This is an important topic from two perspectives: how computers are used in our culture, and how our culture is affected by the use of computers.

Instruction in these topics is usually conducted through a sort of social sciences model, including lectures, student research and discussion of ideas.

Potential careers in computing, for instance, is one topic that lends itself well to student investigation and discussion. Information about the past and current state of computer-related employment can be found in many popular magazines as well as official reports and reference books. Similarly, predictions for future changes in career options are an interesting and important topic for students to consider, and a topic discussed a great deal in business and government publications.

A third facet of computer science is *instruction in programming.* Teaching programming will probably be the least like any experience a new computer science teacher has previously had. In many ways its nearest parallel in schools is the teaching of creative writing.

A good program is very much like a well written short story or poem; it is concise, yet complete in expressing the idea or ideas it is meant to convey. The programmer, like the writer, must have a firm grasp of the matter to be communicated and must be able to provide a coherent, connected expression of it. The vocabulary and grammar in a program must be chosen carefully to express precise meaning to the computer, yet the program must at the same time be comprehensible to programmers who read it. Languages that allow the programmer to choose significant variable names and use a variety of powerful statements are more pleasing to work with for this reason.

All programmers, as a computer science teacher soon learns, have their own style of programming, expressing their own personality and thought processes. The teacher, of course, also has specific ideas about what constitutes good programming style. While the teacher should not demand that students strictly follow one style, some programming instruction should concern writing style. Several tactics used in teaching creative writing can be adapted for use in teaching computer programming.

Students must look closely at material they are writing to become aware of the way they are using the language. In writing, a teacher may force this by directing a student to write a number of sentences or lines of poetry, all beginning or ending with a certain phrase. This way the student must produce sets of ideas related to the given phrase. Programming teachers can give students a similar exercise by focusing on a very small part of a problem solution.

For example, in an interactive system, accepting data from a user and storing it for future processing can be done many ways. The programmer's choice will vary in different cases. Perhaps the user is going to input ten numbers. The programmer will accept and store

these in one manner if the ten numbers are going to be stored, in another if only the largest of the ten will ever be needed, and in yet another if the total of the ten is the data required. If students learn various ways to deal with these cases and other sets of solutions to problems or subproblems, they will see that there are always programming choices.

Control structures also provide a number of options for handling a process. Whether one chooses a counting loop, an increment-test loop or a closed loop with escape will depend on the initial state and desired state at completion. As with the accept and store example, these choices will be made at the procedure analysis level, not at the coding level.

Choices at the coding level can also be made. Selection of variable names and testing constructs will depend on the options available in a given language. Good decisions on these matters are important to the readability of a program, an important element in programming style.

Another way of encouraging students who are programming to focus on the material they are writing is to provide them with subroutines or subprograms which accomplish a particular task when invoked appropriately. Then the student's responsibility is to use these as units, giving correct direction for the units to do the tasks. Providing this sort of programming matrix allows students to accomplish significant computing or make significant errors in a few seemingly minor programming steps.

Some other tactics used in writing classes are also valuable in programming classes. One of these is exposing students' work to numbers of other people for comment and suggestion for improvement. This must always be done in a supportive manner to be of any value as a teaching tool. Having students exchange their work individually and reading and commenting on another student's work is one private way to do this. Having a whole class review a student's program as a group is also possible, as long as care is taken that comment is positive and not threatening to the student whose work is being discussed. This sort of activity is beneficial both to the writer of the program and to the reader, who is exposed to another way of doing the particular program.

Becoming familiar with well written programs and using them for models for programming is another effective means of raising awareness levels for style. In writing classes, students read and sometimes copy good examples of the sort of work they will be doing. Programming students should read and use well written programs so that they have good models to follow; they might also enter code of well written programs as a copying exercise.

Some writers use practices that also apply to programming and which can be taught to students. For example, writers often do a draft of a poem or story, then set it aside for a time before doing the next draft. Many writers spend a lot of time making changes and working over the same copy to perfect it, or a writer may throw away pages or complete drafts of material to start over with a better approach. These are all things that programmers must be willing to do if they want to produce good quality programs.

A computer science classroom is a unique and interesting place. In programming, students are being presented with a new vehicle for creative expression. A teacher can expect a great deal of individuality in programs, with general discomfort from the lack of a single right answer. Teaching computer science may be a difficult and demanding task, but it is also an exciting and gratifying one.

COURSE OUTLINE

Unit 1 — General Introduction

1.1 Students as computer users
- A Personal uses, current and potential
- P Load, run and list a library program
- CE General purpose problem solving tool

1.2 Computer users in general
- A Transition of use, organizations to persons
- P Print, goto, stop/end
- CE Physical parts of a computer

Unit 2 — Using Computers for Learning

2.1 Computer assisted learning
- A Tutorial/programmed learning
- P Variables and variable names
- SI Subjective effect of computer instruction

2.2 Drill and Practice
- A Drill and practice vehicles
- P Input, user interface
- SI Computer caused changes in educational systems

2.3 Numeric computations
- A Activities using much computation
- P Assignment statements, numeric and random number functions
- CE Reasons for and history of computers for numeric work

2.4 Experimenting using computers
- A Aids to decision making
- P Iteration, for/next
- CE Algorithms, writing procedures

2.5 Organizing materials
- A Personal information storage
- P Loops, control structure, if/then
- CE Machine, assembler, high level and ultra-high

Unit 3 — Information Retrieval

3.1 Convenient kinds of information
- A Kinds of information needed
- P Practice with programming user interfaces
- CE Output devices and kinds of copy

3.2 Sports events performance data
- A Automated accessing of sports stats
- P Remark statements and internal documentation
- SI Effect of easily accessible data on events

3.3 Information systems in schools
- A Administrative and library systems
- P Problem analysis, good solution description
- SI Confidentiality of school records

3.4 Community and government information systems
- A National information systems and data banks
- P Subroutines and program structures
- SI Privacy issues related to large data banks

3.5 Business information systems
- A Computer use by businesses
- P Key word information program
- SI Employment in business data processing

3.6 Innovations in business applications
- A Credit cards and EFT
- CE Special applications hardware
- SI Computer crime

3.7 Public information systems
- A Structure of information systems
- CE Physical parts of an information system
- SI Accuracy of information in reference systems

Unit 4 — Computers in Creative Arts

4.1 Computer graphics
- A Contrasting graphic/non-graphic output
- P Graphics program
- CE Evolution of computer graphic capability

4.2 Expressing creativity
- A Tools for creative activity
- P Arrays, lists
- SI New career options in creative arts

4.3 Programming as creative expression
- A Variety in individual programming style
- CE Word processor use
- SI Program planning and team programming

Unit 5 — Modeling and Simulation

5.1 Games as models
- A Accuracy levels in game models
- P More on random number generators
- CE Dedicated-computer games

5.2 Basis of modeling
- CE Modeling a real world example
- P String functions
- A Decision making in modeling

5.3 Learning using simulations
- A Simulations in the classroom
- P Debugging techniques, program testing
- CE Learning to learn with new tools

5.4 Simulation of world events
- A Simulation of emergency situations
- P Simulating population models
- CE World economic models

5.5 Decisions based on simulation
- A Tools for governmental decisions
- CE Non-computer simulations
- SI Social effect of simulation-based decisions

Unit 6 — Artificial Intelligence

6.1 Robotics
- A Defining robots behaviorally
- CE Working robots
- SI Projections for robotics

6.2 Defining artificial intelligence
- A General concepts of AI
- P Intelligence in game playing
- SI Dealing with intelligent machines

6.3 AI in process control
- A Intelligent vs. unintelligent process control
- SI Employment changes in manufacturing
- CE Microprocessors in homes and autos

6.4 Natural language processing
- A Language for user interface
- CE Speech generators
- SI Effect of verbal information delivery

6.5 Computer medical diagnosis
- A Medical computer use
- CE Medical diagnosis as expert systems
- SI Career options in health services

6.6 Computer based counseling
- A Counseling as language processing
- CE Diagnosis vs. counseling
- SI Effects of computer based counseling

Unit 7 — Conclusions

7.1 Judging validity of computer output
- A Appropriate applications of computers
- P Controlling programming errors
- CE Computer system errors

7.2 Learning using a computer
- A Trying out problem solving tactics
- P Creative expression in programming
- SI Computer effect in school systems

7.3 A computer as a personal tool
- A Possible personal computer uses
- P Copyright and protection of programs
- CE Cost/power ratio of computers

7.4 Computers in the future
- A Projected changes for student computer use

UNIT 1 — GENERAL INFORMATION

1.1 STUDENTS AS COMPUTER USERS

Applications

Ask the students to list the kinds of things that computers could do for them. Encourage them to be far ranging and imaginative in their ideas. Suggest they consider what they know about fictional, futuristic machines. If they can't get started, suggest they think about things they know computers can do in the world in general, but be sure they focus on ways computers could be useful to them personally. Keep an on-going list of these uses available throughout the course so that students can add other potential personal uses as they discover them.

Programming

Have each student load, run and list an interactive program. Do not attempt to teach the students to understand individual instructions at this time. Be sure that the library programs they run are of the highest quality, as these will be models for their own work. The topics of the programs are not critical, but they should be highly interesting to your students.

Computer Environment

Consider a computer as a general-purpose problem-solving tool, requiring a program to direct it. Help the students understand the importance of programs in computer use. Introduce the concepts of input and output, processing and storage of programs. Discuss briefly time sharing and single user computers, specifically the benefits of each type of system to the individual user.

1.2 COMPUTER USERS IN GENERAL

Applications

Discuss briefly the transition of commercial computer use from large organizations to personal users. Mention the impact that huge projects such as the census had in encouraging the development of computing, while personal computer use came into focus much later.

Programming

Introduce the PRINT statement or equivalent that causes output to be given to the program user. On the machine, show the students a program sample that uses just the PRINT statement, probably printing a literal. Let the students try some experimentation with what can be done in this manner. You may have to explain the STOP/END constraints here also, if your computer system requires these. This is an excellent time to introduce graphics if you have simple character generated graphics available to you on your computer. You may choose to work with numbers at this point, but it is not necessary, and avoiding a lot of number manipulation here may help some students overcome the idea that all computing is mathematical. Teach your students to use an unconditional GOTO statement with use of the break or escape key to stop the processing of the resultant infinite loop.

Computer Environment

Discuss the essential physical parts of a computer, introducing commonly used terms such as hardware, software, peripherals and interface. Talk about primary and secondary storage and the general need for memory, but be sure to focus on the perspective the user has on the components and their uses, rather than the focus of the computer engineer.

UNIT 2 — USING COMPUTERS FOR LEARNING

2.1 COMPUTER ASSISTED LEARNING

Applications

Have each student run at least one program that presents a lesson or gives them experience with computer assisted learning (using the computer for a tutorial, not for drill and practice). This lesson could be one in which the machine teaches the user to use the computer itself, or it might be related to another school subject such as language, history or geography.

Programming

Introduce the concept of a variable, considering it as a label on a storage location which provides a way of recalling the needed data by that name. Discuss both numeric and string variables, and the allowable names for them in your system. It is not necessary for students to learn how a variable is represented internally in the machine to understand the reason for and the use of variables.

Social Impact

Ask your students how they feel about receiving instruction from a computer. Do they think of the machine as cold and feel they miss the humanity of a teacher? Do they find the added privacy and individualization provided by a computer is desirable? Do they think computer based instruction is appropriate for use in all subject areas? If not, what subjects would work more or less well than others?

2.2 DRILL AND PRACTICE

Applications

Have the students list the various ways they usually do drill and practice, i.e., pencil/paper, flashcards, quiz each other. Have them run a drill and practice program, and then contrast drill and practice using a computer with the other methods they have used. If the program rewards successful students with a game or similar prize, have your students think about this and evaluate its worth to them.

Programming

Show your students the programming statements that allow the user to give input to the program. Most systems have several ways to do this, and although you will want to mention them, at this time it is best to pick the one that creates the fewest complications and have the students use it. Be sure to emphasize interaction with the machine. Additionally, you should discuss information which is printed for the user, and stress the importance of good user/program interactions.

Social Impact

Consider the overall implications for our education systems as more and more computer based education is available, both tutorial and drill and practice. This could not only change the educational process but could radically change the social environment. Many speculative fiction stories include the premise that all education in the future may be done through computer communication, with no human interaction or at large distances from a teacher. Read and discuss such a story, and try to get your students to focus on what this means for young people as learners and for adults as life-long learners.

2.3 NUMERIC COMPUTATIONS

Applications

Some of your students will be taking courses that include some calculation. This will probably be in science, math or vocational classes. Help them investigate the way that having to work required calculations limits the examples and processes that they can study easily. Have your students list some of the applications of numeric calculation used within the school, and outside it.

Programming

Introduce the assignment statement and enlarge on the concept of variables. Again, focus on variables as labels for storage locations in the computer so that students do not confuse them with variables as used in algebraic equations. At this point, introduce the arithmetic operators and concatenation of string variables. Also mention numeric functions, specifically the ones your students may wish to use, e.g. integer, square root and the random number generator.

Computer Environment

Consider the advantages and disadvantages of doing numeric computation using a computer: that the machine calculates quickly and accurately, does repetition with no loss of efficiency, can make large errors very fast. Mention briefly some history of computing showing your students how computers developed in response to a need for numeric manipulation, and that they have since been expanded to do other kinds of processing.

2.4 EXPERIMENTING USING COMPUTERS

Applications

Have your students discuss the process they have used in deciding how to accomplish a project. Take a specific example, such as building a small structure like a shed or a garage and consider how options are chosen. Help them see ways they can consider more options if they have computational power to assist them with analyzing the choices. In the building example, this might mean figuring the cost difference resulting from various styles of roofs.

Programming

Introduce the idea of iteration with an indexed loop such as the FOR-NEXT loop in BASIC. One very useful and easy to understand use of an indexed loop is the empty counting loop. This is a timer used for delaying execution of a program for the sake of the human user. The idea of "counting to 100" is one most students are already familiar with.

Computer Environment

Spend some time developing the idea of an algorithm, so that your students start to understand the importance of clearly thought out, clearly specified instructions that a machine can follow. There are many classroom activities that have been developed to illustrate this concept. Try some activities as well as discussing examples of algorithms the students already use. The students should recognize the necessity for clear, step-by-step specification in creating procedures for a computer to follow.

2.5 ORGANIZING MATERIALS

Applications

Have your students consider some tasks they do which might be made easier by computers. For example, doing research for a paper could include a computer search for the information needed. Students' class notes could be filed and then accessed by storing them in a computer. Students might also want a computer to keep track of schedules for exams or due dates for assignments.

Programming

Have your students experiment with the loops they have already learned. Introduce the IF-THEN construct so that they will see several examples of how this can be used. Generally the closed loop with an IF to escape is easiest to understand. Students will need to have quite a bit of experience programming with these kinds of control structures before they become comfortable using them.

Computer Environment

Discuss the various levels of computer languages: machine language, assembler and high level languages. Be sure the students understand that a computer must have the kinds of languages we usually use for programming translated into code it can understand. Do not expect the students to be able to recognize languages other than the one in which they are programming. The point, rather, is that they know that many languages exist and that each language serves a particular purpose. Some discussion of the ultra-high level languages now being developed should also be included.

UNIT 3 — INFORMATION RETRIEVAL

3.1 CONVENIENT KINDS OF INFORMATION

Applications

Have the students consider what kinds of information they seek in their daily lives, and the sorts of information they would enjoy having available. They should consider what their current sources of information are, and what kind of activity is necessary for them to use any information sources.

Programming

Have the students work with a simple program that allows the user to input a value and then print one of a set of messages depending on the input value. At this point students should be able to write a procedure showing the series of decision statements that can be used to accomplish this task. Encourage them to experiment with using both numerical and string variables for the key variable, and to use the variable itself as part of the messages that are printed by the program. Remind the students that a computer is of no value if the user cannot understand the output, so careful consideration must go into user directions and presentation of output.

Computer Environment

Discuss the various types of output devices that are common in computer systems. Consider output in terms of the human/machine interface. Examples of output from devices such as a line printer, plotter or printing terminal help students recognize differences in these media. Have your students also consider computer output that is in machine readable form itself. Talk about different occasions when people need hard copy of output and when temporary copy, such as what a CRT produces, is sufficient.

3.2 SPORTS EVENTS PERFORMANCE DATA

Applications

Talk about the various athletic events that students see in which statistics on players' past performances are continually available for comparison with current play. Similarly, statistics are kept by coaches on the performance of students playing on school teams. Some of your students may have kept stats, and may be able to report on the kind of information gathered for their teams.

Programming

Discuss REMARK statements and the importance of internal documentation in programming. Have the students look at listings of some programs with good internal documentation and try to write out the procedure being used in the program. They should not expect to understand each statement, but to be able to follow the flow of the problem solution. At this time do not use programs with subroutines. However, students should be able to handle programs with indexed loops.

Social Impact

Have the students consider how this accessibility of information to coaches, team players and others affects the task the people in professional sports have to accomplish. Discuss the possibility that too much data could be gathered for it to actually be of benefit to the people who have it. Expand this idea into other areas, particularly back to a topic your students have indicated they would like a lot of information about. Get them to consider the possibility of a person or system becoming inoperative because of too much data input.

3.3 INFORMATION SYSTEMS IN SCHOOLS

Applications

Have the students inquire into the ways automated data processing is used within your school. Besides administrative applications, some computers may be used for book circulation records or computer searches may be available through your library. Even if these are not in current use, the library provides a good basis for considering both information retrieval systems and record keeping applications of computers. Have a person from your school who uses computers as a regular part of their job come in and talk to the class about it.

Programming

Continue discussion of problem analysis, having the students write procedures for more complicated problem solutions. Introduce some kind of graphic representation of a problem solution, flow charting if you strongly prefer it, or some other way of diagramming the process being used. If you choose to use flow charting, be sure that too much emphasis is not given to the particulars of a large number of flowcharting symbols, but rather focus on the idea of using a picture to help clearly understand the attack on the problem.

Social Impact

Have your students spend some time considering the information kept in school records, particularly from the point of view of the individual's right to privacy. Get a counselor or administrator to talk about the safeguards that are used to protect student records, including those safeguards that are used to guard computer files. Also discuss the ways reports that are sent to state departments and other agencies are handled so as to protect individual students.

3.4 COMMUNITY AND GOVERNMENT INFORMATION SYSTEMS

Applications

Have your students discover ways in which computers are used for information processing in their own community. They should also investigate ways that state and federal governments gather and use data. Of particular interest might be interlocking systems of police files, car registration, traffic control and planning, weather information and satellite surveillance. Students should be able to find information about these types of national data banks in many popular magazines and newspapers.

Programming

Introduce the idea of a subroutine and discuss the advantages of using subroutines in programming. Show your students how to use a subroutine such as a delay loop subroutine for timing in a program, or a subroutine that does some numeric operation on a given variable. Be sure they think about portability from one person to another as one of the advantages of writing programs with subroutines.

Social Impact

Investigate further the questions about privacy that arise as a result of quick and complete access to integrated data files. Contrast this situation with past procedures, when it was very difficult for persons to get data about an individual unless they were physically nearby. Even though more data may have been gathered about the individual, fewer people had access to it. Emphasize to your students that the modern rapid transmittal of data to other areas or other computer systems makes maintaining privacy a much more difficult problem. Talk about some of the attempts that are made to control this problem.

3.5 BUSINESS INFORMATION SYSTEMS

Applications

Discuss some of the various ways a business can use computers; most of these are information storage and retrieval applications. Consider examples of the inventory type, in which a record of items on hand is kept. Also consider transaction records, in which the information being maintained is a list of happenings, such as sales. Focus on the changes that using a computer creates in this sort of record keeping and the advantage of using computers for access to timely information because of computing speed.

Programming

Set up a partial program consisting of a number of subroutines that print out information on various topics. Have your students write the main program that accepts a word from the user and calls the correct printing subroutine for that key word. Be sure your students note the difficulties caused by the need for exact matching between the key word and the input value. After your students have learned about string functions, they may want to alter this program to provide for the program making a guess at the keyword intended if the user does not input an exact keyword.

Social Impact

Invite some business people in to talk about how computers have affected their way of doing business, or their job description. A management point of view and an employee viewpoint might both be helpful. Be sure that one of the topics covered is career information, so students will be aware of the impact computers have had on employment in the business area.

3.6 INNOVATIONS IN BUSINESS APPLICATIONS

Applications

Present your students with some information about the way credit cards and Electronic Funds Transfer systems work. Have them consider the perspective that money is actually information; it has value because of what it represents, not in itself. Extending this information representation to credit cards, bank balances and checks is a way our society increases its flow of money operations. Again, have your students consider the ramifications of the speed and timeliness of information provided by computers.

Computer Environment

Discuss some innovations created by combining modern hardware with computing. One of these that students are probably familiar with is the bar code which is read by a light sensitive reader. Plan a trip to a library that uses this type of coding for a book checkout, or to a market that has installed bar code readers for the cashiers. Another such process is automated banking; discuss the need for and the means available for positive identification of a person who is using such a system.

Social Impact

Spend some time discussing "computer crime." Have the students investigate the kinds of crime that usually appear under this label. They should realize that the criminal is using the computer as a tool just like any other user; the question of the propriety of an activity is not determined by the tools used. Certain types of criminal activity are much easier, however, when computers are used and the activity is not regularly monitored by a person.

3.7 PUBLIC INFORMATION SYSTEMS

Applications

Discuss some possibilities for ways an information system could be structured: as a library look-up, as a news dispersion system, as an electronic mail service, as an automatic book printer. Investigate some information networks that already exist in the U.S. and other countries to provide individuals with some types of information. Talk about the implications of government or corporate monopolies of these networks.

Computer Environment

Consider some of the physical means currently available and being planned for large scale information systems: telephone, television cable, satellite. Be sure the students realize that the provision for two-way communication is an essential part of these systems, making them different from broadcast communication systems. Contrast the differences that must be built into a system that is open to public use with a system dedicated to one use, such as an airline reservation system.

Social Impact

Consider the impact of a piece of wrong information entered into a system which is used by a large number of people. Discuss the possibility that in some special instances, there may be only one central depository of information on a topic. Project from students' current experience with newspapers and magazines that include much propaganda, to the potential for social manipulation integral to large information systems.

UNIT 4 — COMPUTERS IN CREATIVE ARTS

4.1 COMPUTER GRAPHICS

Applications

Have your students run a game that includes graphics as a part of the information the game player uses, and if possible, the same game using only word interaction for input and output. Also run some programs, possibly a statistical manipulation, that give results both in numeric form and by graph, so that the students can compare them.

Programming

Teach your students about graphics, centering on graphic capabilities of the system you use. Have them consider graphics as an overall concept, separate from a means of delivering computer output. Show them how to do character based graphics as a step to point based graphics. Allow them a lot of time to experiment with these techniques. Have your students write a program that includes the programming statements they have learned but now focus on graphic output.

Computer Environment

Discuss the development of graphics at the personal computer level. Show the students exampls of computer generated graphics and discuss computer controlled enhancement of other graphic techniques such as are used in movie making. Mention some of the special graphic input and output devices that are available and being developed, where communication with the computer is analog rather than digitized.

4.2 EXPRESSING CREATIVITY

Applications

Have your students think about the kinds of things they do to express creativity such as drawing, making music or writing. Have them consider ways in which computers could be used in making this process easier. There are a large number of options for using computers as tools in the process of expression, e.g. composing and notating music or using a text processing system to produce the work. Additionally, there are various kinds of creative processes which are totally dependent on having a computer as the mode of expression such as computer music or computer controlled sculpture.

Programming

Introduce your students to arrays, starting with one dimensional arrays used as lists. Have them write a program which keeps a list of some variable, and does some processing of that list by using a counting loop or an indexed loop. Again, this may well be focused on using graphics for the output, using the array and the loop to do repeating graphic patterns. You will probably not want to teach multidimensional arrays to students at this level, but some students will be interested in using them.

Social Impact

Investigate the changes that professionals in the creative arts have made as a result of computer use in these fields. Animation and television advertising are two areas where students will be able to see the most current techniques being used. Have them inquire into the kinds of changes people in this area are having to make and the potential for computer specialists to work in this career area.

4.3 PROGRAMMING AS CREATIVE EXPRESSION

Applications

Discuss with your students the experiences they have had so far in writing programs, considering particularly the differences they have noted in the way various people program a solution to the same problem. Encourage interaction between the students who by now will have discovered a natural affinity for programming and the students who have some difficulty expressing themselves this way. Draw parallels between this and such modes of expression as poetry and painting.

Computer Environment

Let each of your students experience working with a text processor. Have them use it as they would for doing their school work, for example a composition or report. Point out that the most common use of text processors is in business environments, but be sure the students understand that text processing is one of the personal computer uses that is actually being used a great deal, in contrast to many others that are still "potential" uses.

Social Impact

By this time your students should have had some experience with working on programming as a team. Discuss with them the need for team programming on most significant computer programs. Have them consider the complexities that working as a team creates, whether in programming or elsewhere. List the tactics that programming teams use to deal with the division of tasks when doing team programming, and the control of the interconnections between segments of large programs.

UNIT 5 — MODELING AND SIMULATION

5.1 GAMES AS MODELS

Applications

Have the students review the kinds of games that they have had an opportunity to play on a computer, and discuss which of these games is a model of a real world event, including historical events and projected future events. As they discuss these games, ask them to comment on the accuracy of the model; what in the real world event being modeled was included and what was left out? Have the students consider the way that more accurate models involving more detail make more interesting games, but beyond a point more detail and more factors make the game and the model difficult, then impossible to work with.

Programming

Discuss further with your students the concept of random numbers, and the random number generators that are available on your computer. Using a program such as a dice game that involves chance, have your students make changes in the statements that use the random number generator and then observe the resulting change in the behavior of the program. If you have a simulation of a probability machine, the effect of altering random number use can clearly be shown.

Computer Environment

Consider some of the ways that computer games are available to players in addition to those played on general purpose computers. Have students investigate the economic impact that computerized gaming has made. Give your students some information on the historical interest that computer programmers have had in games. Draw parallels between the rules specified for playing games and the procedures that are written for programming.

5.2 BASIS FOR MODELING

Computer Environment

Have your students consider a real-world situation that they might want to model. For example, they might make a model of the lunch room with people eating, people waiting to be served, people clearing trays. They should first list as many variable situations as they can that might be taken into consideration when looking at the dynamics of this activity. Next, they should consider the complexity of modeling this many variables, and develop a list of the variables in priority of importance, determining which of the variables are essential and which might be disregarded.

Programming

Introduce the string functions that are available in your system, particularly the ones that find or modify substrings of string variables. Some of your more advanced students may be interested in using functions that manipulate characters using their machine language representation, but the language level string functions in BASIC have sufficient power to allow students to accomplish some very interesting programming.

Applications

Help your students come to realize that in doing modeling of any form, whether for a computer or not, it is necessary to simplify and to make some assumptions. There will always be some difference between the real world and the model of that part of the real world, but this is acceptable as long as anyone using the model or a simulation with the model keeps this limitation in mind. Consider some erroneous conclusions that could be derived from the model you and your students discussed earlier.

5.3 LEARNING USING SIMULATIONS

Applications

Discuss with your students some of the simulations they have used in classes such as social studies or the sciences, or if your school does not use simulations in these classes, run at least one of this type for your students. Have them list other simulations of this type that are helpful as enrichment in a standard classroom. Also, have them discuss training type simulations such as those used by pilots or astronauts, which may require special equipment tied to a computer.

Programming

Talk with your students about some of the specific techniques that can be used in debugging programs. Emphasize that a well planned and well structured program is much more readily debugged. Suggest ideas for testing programs and good kinds of sample data to use for trying out a program.

Computer Environment

Talk with your students about the way their educational process has taught them to learn. Consider debugging as an example of doing deductive reasoning and testing a hypothesis. Using this parallel between learning to debug and doing deductive reasoning as a life skill, discuss the educational process as a simulation of the real world.

5.4 SIMULATION OF WORLD EVENTS

Applications

Discuss a number of situations under which error conditions must be considered, such as things going wrong with a space shot, for which the people involved in the situation would want to be prepared. Also, consider training methods that include simulations of emergency or disaster situations, such as operating power plants or military training.

Programming

Have your students write a simple simulation of a population growth model, including average birth and death rates for a number of countries in the world. They might include some control factors that would, for example, modify the birth rate depending on the population density or food availability. While they will not be able to do a very complex model, they will become aware of the number of factors involved.

Computer Environment

Have some students investigate and report on some of the well known simulations of world economics and of world population studies. Discuss the sources of data used in these simulations and the variety of conclusions that can be made from the results of the simulations. Focus on the importance of using valid input data as well as having a valid model from which to work.

5.5 DECISIONS BASED ON SIMULATION

Applications

Discuss various kinds of simulations that are used as predictors in government decisions. Particularly discuss the economic models that are used to support decisions that the federal government must make about inflation and recession, employment, tax structures and other financial matters. Also consider simulations of defense strategies, health and safety situations such as fallout patterns or energy shortages.

Computer Environment

Have your students consider some simulations that are not computer based: board games, training exercises, much of what goes on in classrooms. Consider the factors that make computers important in some simulations, the much larger amount of detail and data that can be handled, and the speed with which it can be done. Discuss the implications of this for organizations that do not have the power/money to have very large computers available.

Social Impact

Consider the effect that government policies have on the national economy and the resulting effect this has on the individual who must deal with that economy. Discuss other responses that people make as a result of simulations giving predictions of events such as weather forecasting, election results, effects of wars of various scales.

UNIT 6 — ARTIFICIAL INTELLIGENCE

6.1 ROBOTICS

Applications

Have your students discuss the various robots that they are familiar with from movies, television or novels. Use these examples as a basis for creating a general definition of a robot. From this definition, which will probably be oriented toward the behavior that robots are generally considered to exhibit, have your students talk about the control mechanism that is involved in creating this behavior. Expand your definition of robots to include non-humanlike machines.

Computer Environment

Have your students investigate some of the robotic extensions of computer systems that exist now. Show them, via films or pictures as necessary, some robots. Contrast real working robots with fictional robots. Discuss how a robot could be programmed and what things might be built in as direct level functions.

Social Impact

Have your students read some fictional accounts of robots, sampling from various eras of their appearance in stories. Look especially for the recurring themes that appear when authors are writing about robots: the question of assumed humanity of the robot; constraints on robots' activities and freedom; immortality or robots compared to humans; robots continuing to learn and gather information beyond the capabilities of humans; robots communicating together and acting together beyond the control of humans.

6.2 DEFINING ARTIFICIAL INTELLIGENCE

Applications

Discuss with your students a general definition of artificial intelligence. Have them consider the kinds of things humans do that require intelligence, and inversely, how we define intelligence based on such behavior. Focus on the concept of responsiveness to sensory input from the environment as a working definition of intelligence. Refer to the concepts discussed earlier about modeling and simulation, and how these concepts are integral to modeling intelligent behavior on computers. Contrast heuristics with algorithms.

Programming

Choose a simple game in which the computer is demonstrating some intelligence such as tic-tac-toe, and have your students write out the specifications under which the machine is making choices on how to proceed. Have them modify this decision criterion and modify the game program, then compare the resulting game behavior. Consider the increasing complexity of programs that try to allow the computer more powerful heuristics.

Social Impact

Talk about the kinds of things that computers can do as intelligent machines. Consider what people should do, and the kinds of skills they should have to get along with and make good use of these capabilities of computers. Discuss the role divisions that make it possible for people and computers to supplement each other's abilities.

6.3 ARTIFICIAL INTELLIGENCE IN PROCESS CONTROL

Applications

Discuss with your students the various types and the large amount of production and assembly line work that is done by machines. Consider the repetitive, unintelligent sort of production in which a machine does one unalterable task unless interfered with by a human. Compare this with a kind of production machine (robot) which can monitor itself and monitor the product being made, and change its behavior according to the needs of the process. Your students may want to learn about constructors, machines that invent machines, as the next logical step in this development of machines.

Social Impact

Discuss the impact that computer controlled production has had and can be expected to have in the future on employment in assembly occupations. Contrast the cost per work station in a factory with that in other work arenas. Have your students consider the type of production employment that is least likely to be affected by computerization. Be sure they are aware, however, of the portion of workforce in this sector.

Computer Environment

Have your students investigate and discuss the uses of microprocessors in homes and in cars. Most of these will be of the continuous monitoring type. In some cases such as environment control, however, the computer controlled system is able to respond to the input it is receiving and cause change in the environment it is sensing from. Be sure your students see the difference in the level of power that this implies.

6.4 NATURAL LANGUAGE PROCESSING

Applications

Review with your students their experience with computers speaking to them through their user interface. Some of this may have been audible, but most will have been written. Their practice with writing directions for program users, plus their experience with manipulating string variables, should give them an idea about ways that a computer can be made to appear to be able to speak human language. Discuss with them the additional levels of complexity involved in understanding speech, wtih all the possible patterns humans use. Review briefly the history and current level of success of language analysis programs.

Computer Environment

Discuss with your students some of the special computer controlled tools that make use of speech generators. They will probably be quite familiar with tools that teach spelling, and possibly with language translation tools. They might also know about machines that read written text for the visually handicapped, or of voice input devices. Encourage them to speculate on other potential tools of this type.

Social Impact

Discuss the impact of speaking computers on the way people acquire information. Compare the parallels from written newspapers and magazines to television and radio news, with information retrieval in written form and information available via sound. Have your students consider what computer analysis of wire-tapped conversations could cause to happen. Also talk about the ways that having voice input to computers would affect various kinds of jobs.

6.5 COMPUTER MEDICAL DIAGNOSIS

Applications

Have your students list the ways that a computer could be helpful in diagnosing medical problems. They should consider several categories of activity for computer use in this field: simplest may be recording data on the patient's history and current symptoms; sophisticated computer controlled equipment may perform tests and analyze the results; and based on the input data, a computer system might suggest possible diagnoses, along with probabilities that each diagnosis would be assigned.

Computer Environment

Discuss with your students the concept behind an "expert" system, in which the goal is to have a computer system that can replicate the conclusions that an expert human will make in a given situation. Programs that do medical diagnosis can be considered to have this goal. Have your students list the sorts of information a doctor gathers and uses to make a diagnosis of an illness, then talk about which of these a computer could handle readily.

Social Impact

Consider the changes that computers have made in career options in the health services field. This might include investigation of new jobs that did not exist before computing entered the health field, e.g. technicians who perform and analyze computer based tests such as heart monitoring. Other jobs have been modified greatly, for example intensive care nursing. Discuss the general question of responsibility for errors as more and more complex machinery comes between the patient and the health care professional.

6.6 COMPUTER BASED COUNSELING

Applications

Have your students run a program (such as ELIZA by Wiezenbaum) that does counseling on a language processing basis. Explain to the students the basis under which such a program operates, and how the conversation between the user and the machine is maintained. Mention the need of a highly structured system and somewhat limited vocabulary in the language being used as a basis for such a program, given the current state of language processing.

Computer Environment

Discuss with the students the ways that diagnosis differs from counseling, and ways that medical health may be different from emotional health. Have the students recall how they responded to being taught by a machine instead of a teacher, and try to relate this to feelings about counseling by machine rather than by a human.

Social Impact

Consider with your students the ramifications of counseling by machine. Discuss job counseling, academic counseling, and legal counseling as well as psychological counseling. Talk about the economic effects of machine counseling and the resulting greater access that many people would have to counseling via machine. Also discuss the quality and validity of such counseling for different purposes and levels of need on the part of the user.

UNIT 7 — CONCLUSIONS

7.1 JUDGING THE VALIDITY OF COMPUTER OUTPUT

Applications

Discuss when a computer is being appropriately applied to a problem and when computers, particularly in their present state of development, are better not applied to a problem. Talk about the difficulties and inefficiencies that nearly always happen when a computer is first applied to a given problem, even when that problem is well suited to solution by a computer. Contrast applying computers to one-time tasks with using them for tasks done repeatedly.

Programming

Discuss the kinds of programming errors that can be made which might invalidate the results produced by a program. Focus on conceptual errors and erroneous assumptions in addition to programming bugs. Consider also the possibility of mistakes in the data or other input being used. Discuss the programmer's responsibility to prevent as many of these errors as possible, and some tactics used for this purpose.

Computer Environment

Discuss some of the common mistakes that are blamed on computers (billing errors, production schedules not being met, records being lost). Have the students consider ways that some of these sorts of problems might be eliminated by the people responsible for these systems. In contrast, have them discuss the individual's responsibility as a user of programs that someone else has written, including testing of a package to be used, and applying a package only to a use for which it was intended.

7.2 LEARNING USING A COMPUTER

Applications

Discuss using computers as a vehicle for trying out problem-solving tactics. Consider how the process of thinking through procedures and then coding them and trying them out allows the programmer to experiment with different approaches to problems. Additionally your students should consider the ways that computer support of other intellectual activities can be provided in terms of information retrieval, word processing and arithmetic processing.

Programming

Consider the creative work done in programming, including the attack on the problem, the procedure used to solve the problem, the style of the coding in the language and the deductive investigation when testing and debugging a program. Discuss how learning to program has provided a set of tactics that can be applied to other creative problem-solving tasks.

Social Impact

Talk about the impact that computers have had in the educational process, specifically within your school, and additionally in the rest of the world. Discuss which segments of the population have been first into the educational use of computing and which use it the most. Speculate on the attitude changes that result from such use of computers.

7.3 A COMPUTER AS A PERSONAL TOOL

Applications

Have your students discuss the ways computers are really of use to them personally, and ways they could be useful if unlimited computer power were available to the students now. Compare the list of applications that you made at the beginning of the course with a list that students can now make of things that are currently available. Consider the ways that their perspective on computer use has changed.

Programming

Have the students consider their feelings about respecting copyright and proprietary interest of commercially available software, now that they have had some experience with the skill and effort required to write good programs. Discuss briefly the legal situation with respect to copyright, and compare this with copyright of other materials such as books or records and tapes. Consider some methods being used to prevent the illegal copying of software.

Computer Environment

Discuss the cost/power ratio of computers and how this relationship has changed since the first computers were commercially available. Consider some projected trends in the cost of hardware, software and personal computer systems. Compare the cost and time required for a computer to do arithmetic computations to the cost and time for a person or person plus calculator to do the same computation. Review the other costs involved in computing, beyond the cost of the machine time.

7.4 COMPUTERS IN THE FUTURE

Applications

Discuss the way computers could fulfill students' needs now if the technology were more advanced, i.e., more sophisticated languages, large information systems available inexpensively, smaller and less expensive personal computer systems. Consider the results now if all students in the school had free access to computers whenever they wished to use them. Talk about what must change if computing is to become an everyday activity for them and for other students. What social consequences are there if some students have computing available and others do not?

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PERIODICALS

Periodicals marked **T** will be of interest to the teacher, while the ones marked **S** will be of interest to both the teacher and the student. Prices are effective as of July 1982.

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Jean Rogers, the author of this booklet, is currently studying and teaching at the University of Oregon. Her academic background includes extensive coursework in computer science, mathematics and education. She is now working on a doctorate in Computer Science Education.

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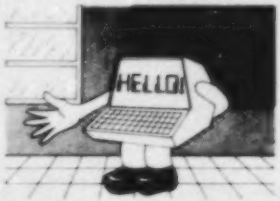

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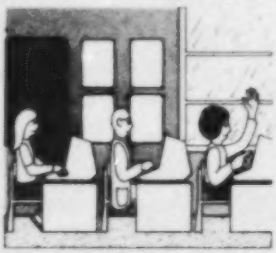

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